a voltage signal at one of the first terminal or second terminal of the switch has crossed a voltage value equal to the second reference voltage.

[0024] In some implementations, the control circuitry includes, a phase detection circuit, an integrator circuit, a third comparator, a flip-flop, and a controller. The phase detection circuit can be coupled with the first-comparator output terminal and the second-comparator output terminal. The integrator circuit can be coupled with the phase detection circuit. The third comparator can include a third-comparator output terminal, a third-comparator first input terminal electrically connected to the first terminal of the switch, and a third-comparator second input terminal coupled with the integrator circuit. The flip-flop can include a reset terminal, a clock terminal electrically connected to the third-comparator output terminal, and an output terminal electrically connected to the control terminal of the switch. And, the controller can be coupled with the reset terminal of the flip-flop, and configured to provide a reset signal to the flip-flop.

[0025] The controller can be configured to provide the reset signal to turn the switch OFF after a switch ON duration. The switch can be a field effect transistor, where the control terminal is a gate of the transistor, the first terminal is one of a source or a drain of the transistor, and the second terminal is the other of the source or the drain of the transistor.

[0026] The first reference voltage can be selected based on the threshold voltage of the transistor. The phase detection circuit can be to determine a phase difference between an output signal from the first comparator and an output signal from the second comparator. The controller can be a PWM generator and the reset signal is a PWM signal.

[0027] Particular implementations of the subject matter described in this specification can be implemented so as to realize one or more of the following advantages. Implementations may permit the use of lower operating voltages for tuning circuit components. Some implementations may reduce voltage and current stresses on tunable circuit components. Some implementations may permit dynamic balancing of resonator coils. Some implementations may improve the accuracy of zero voltage switching (ZVS) controls.

[0028] Embodiments of the devices, circuits, and systems disclosed can also include any of the other features disclosed herein, including features disclosed in combination with different embodiments, and in any combination as appropriate.

[0029] The details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages of the subject matter will be apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. **1** shows a block diagram of an example of a wireless power transfer system.

[0031] FIG. **2** shows a block diagram of an example wireless power transfer system including an impedance matching network.

[0032] FIG. **3** depicts an example of a dynamically tunable capacitor circuit in accordance with implementations of the present disclosure.

[0033] FIGS. **4**A-**4**C depict examples of voltage signals applied to the tunable capacitor circuit.

[0034] FIG. **5** depicts an example of a wireless energy transfer system including a dynamically tunable capacitor circuit.

[0035] FIG. **6** depicts the dynamically tunable capacitor circuit with an example of a first implementation of the control circuitry.

[0036] FIG. **7** depicts the dynamically tunable capacitor circuit with an example of a second implementation of the control circuitry.

[0037] FIG. **8** depicts the dynamically tunable capacitor circuit with an example of a third implementation of the control circuitry.

[0038] FIGS. **9**A-**9**D depict graphs of exemplary control signals in the control circuitry of the third implementation.

[0039] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0040] Wireless energy transfer systems described herein can be implemented using a wide variety of resonators and resonant objects. As those skilled in the art will recognize, important considerations for resonator-based power transfer include resonator quality factor and resonator coupling. Extensive discussion of such issues, e.g., coupled mode theory (CMT), coupling coefficients and factors, quality factors (also referred to as Q-factors), and impedance matching is provided, for example, in U.S. patent application Ser. No. 13/428,142, published on Jul. 19, 2012 as US 2012/0184338, in U.S. patent application Ser. No. 13/567,893, published on Feb. 7, 2013 as US 2013/0033118, and in U.S. patent application Ser. No. 14/059,094, published on Apr. 24, 2014 as US 2014/0111019. The entire contents of each of these applications are incorporated by reference herein.

[0041] Power transfer systems may rely on electronic circuits such as rectifiers, AC (Alternating Current) to DC (Direct Current) converters, impedance matching circuits, and other power electronics to condition, monitor, maintain, and/or modify the characteristics of the voltage and/or current used to provide power to electronic devices. Power electronics can provide power to a load with dynamic input impedance characteristics. In some cases, in order to enable efficient power transfer, a dynamic impedance matching network is provided to match varying load impedances to that of the power source.

[0042] In some applications such as wireless power transfer, load impedances for a wireless power supply device may vary dynamically. In such applications, impedance matching between a load, such as a resonator coil, and a power supply of the device may be required to prevent unnecessary energy losses and excess heat. For example, the impedance associated with a resonator coil may be dynamic, in which case, a dynamic impedance matching network can be provided to match the varying power supply impedance (e.g., a device resonator) to that of the device. In the case of a wirelessly powered device, power supply impedances (e.g., a device resonator coil) may be highly variable. Therefore, an impedance matching network can be supplied between the device resonator coil and the power source of the device (e.g., battery or battery charging circuitry) to promote efficient transfer of power. Accordingly, power transfer systems transferring and/or receiving power via highly resonant wireless energy transfer, for example, may be required to